United States Patent [19]

Caduff

[11] **Patent Number: 4,797,969**

[45] **Date of Patent: Jan. 17, 1989**

[54] **BUILDING EXTERIOR CLEANING APPARATUS**

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[21] Appl. No.: **1,763**

[22] Filed: **Jan. 9, 1987**

[51] **Int. Cl.**[4] **A47L 1/04**
[52] **U.S. Cl.** **15/302**; 15/103
[58] **Field of Search** 15/302, 421, 103

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,425,082	2/1969	Hetman	15/52
4,112,535	9/1978	Wild et al.	15/302 X
4,198,724	4/1980	Fisher et al.	15/302

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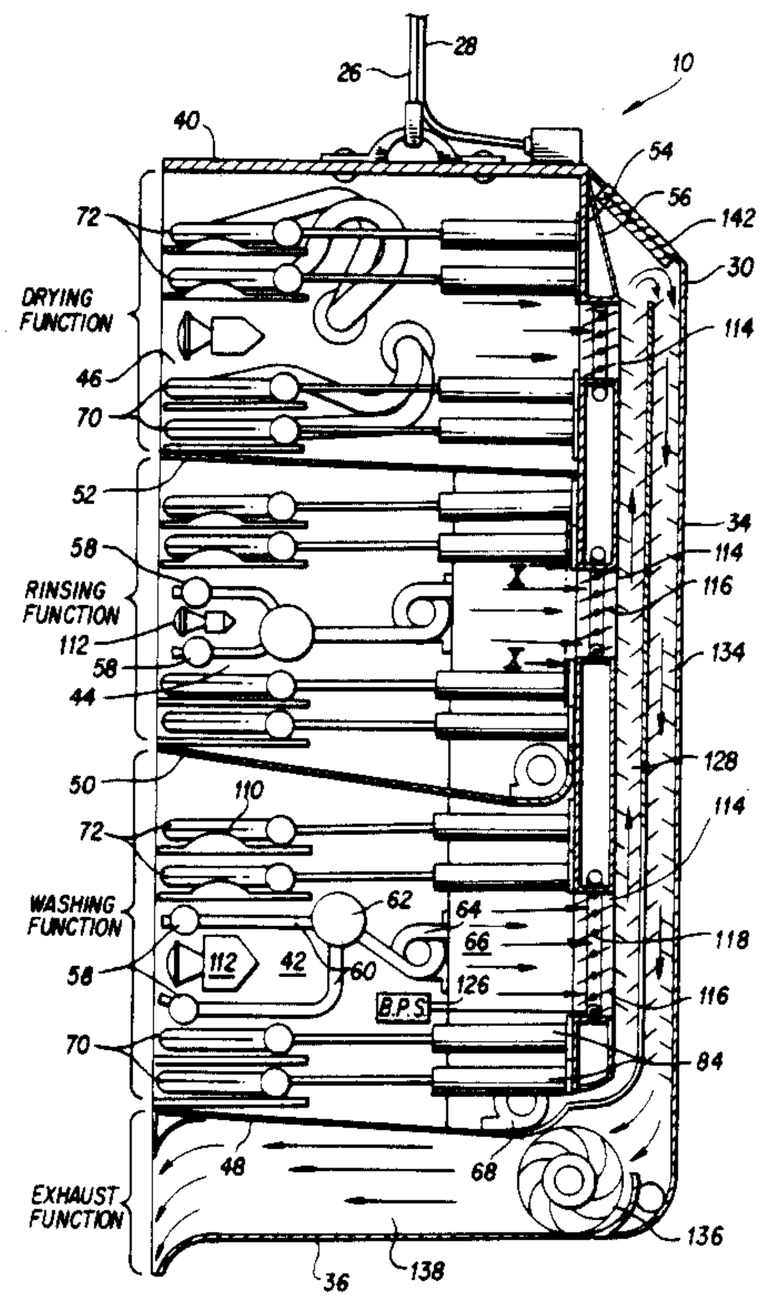
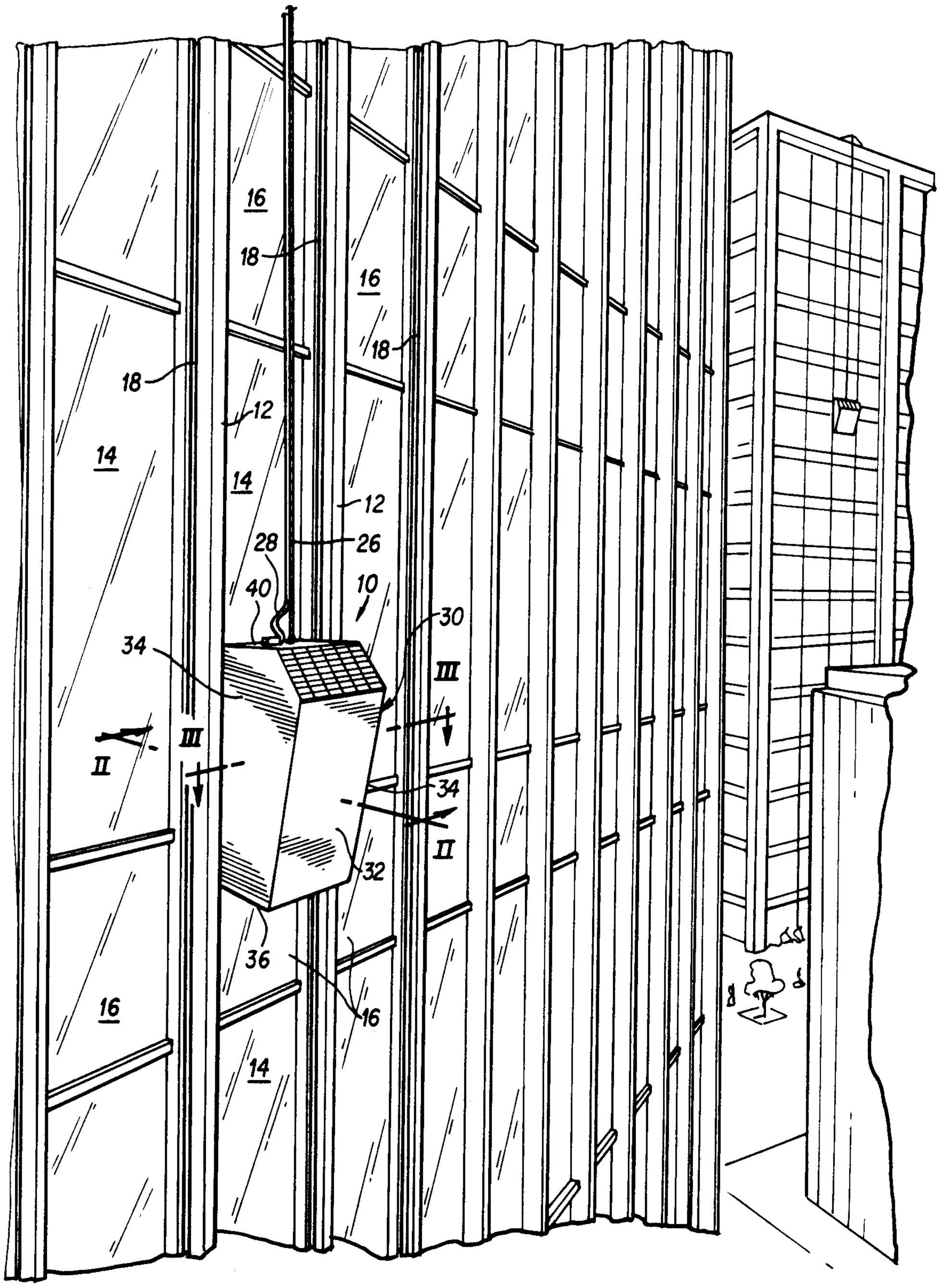
Primary Examiner—Chris K. Moore
Attorney, Agent, or Firm—Wigman & Cohen

[57] **ABSTRACT**

The present invention is directed to a self-contained apparatus for cleaning the vertical surface of a building exterior, including washing, rinsing and drying the windows. The apparatus is positioned by an operator above a vertical row of windows and then remotely operated to clean the exterior building surface as the apparatus descends. The apparatus consists of a housing having a washing chamber, a rinsing chamber, and a drying chamber. The washing chamber has a plurality of cleaning fluid spray heads, a sonic agitator for impinging sonic energy onto the cleaning fluid to aid in removing dirt from the windows, air seals for retaining the fluid in the chamber, and a plurality of air wipes for removing the fluid from the building surface. The rinsing chamber has a plurality of rinsing liquid spray heads, a plurality of air seals to contain the rinsing fluid within the chamber and a plurality of air wipes for removing the fluid from the building surface. The washing chamber, rinsing chamber, and drying chamber are provided with openings communicating with a passageway ending in an exhaust outlet. An exhaust blower disposed in the passageway maintains a negative pressure in each of the chambers. A plurality of axially rotatably mounted vanes are disposed in the openings in order to regulate the negative pressure. Pressure sensors in each of the chambers are operatively connected to the vanes to vary the sizes of the openings to regulate the pressure in the chambers, in response to the actual pressures therein.

19 Claims, 7 Drawing Sheets

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III
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FIG. 1

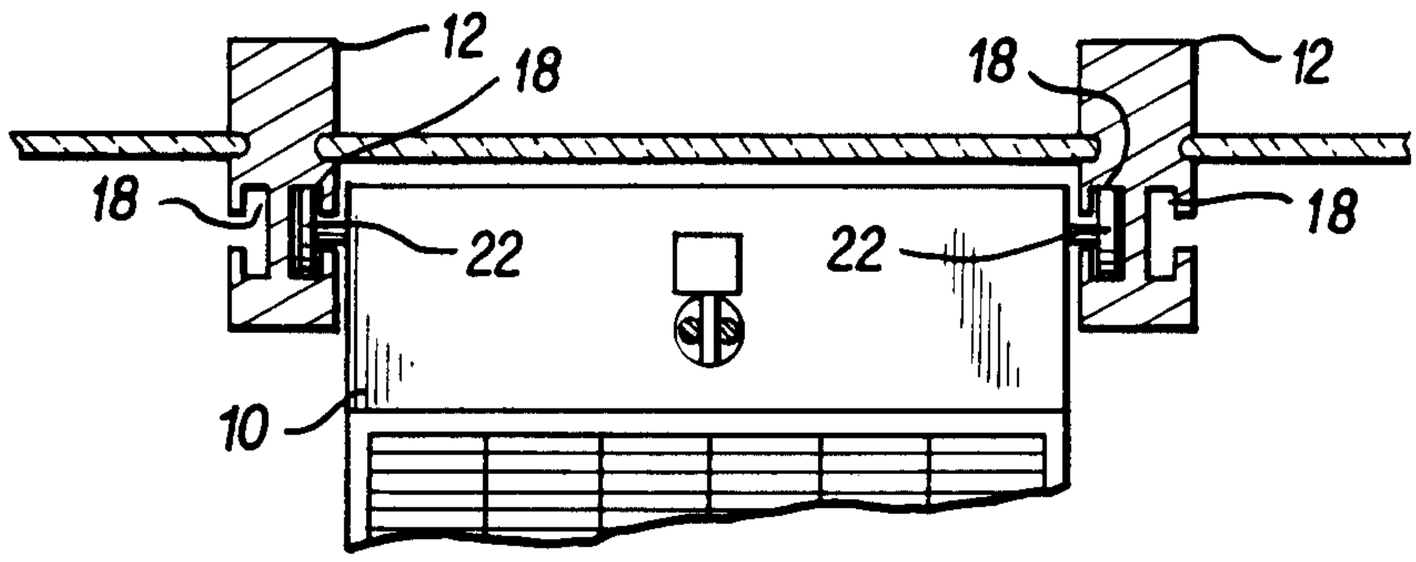


FIG. 1a

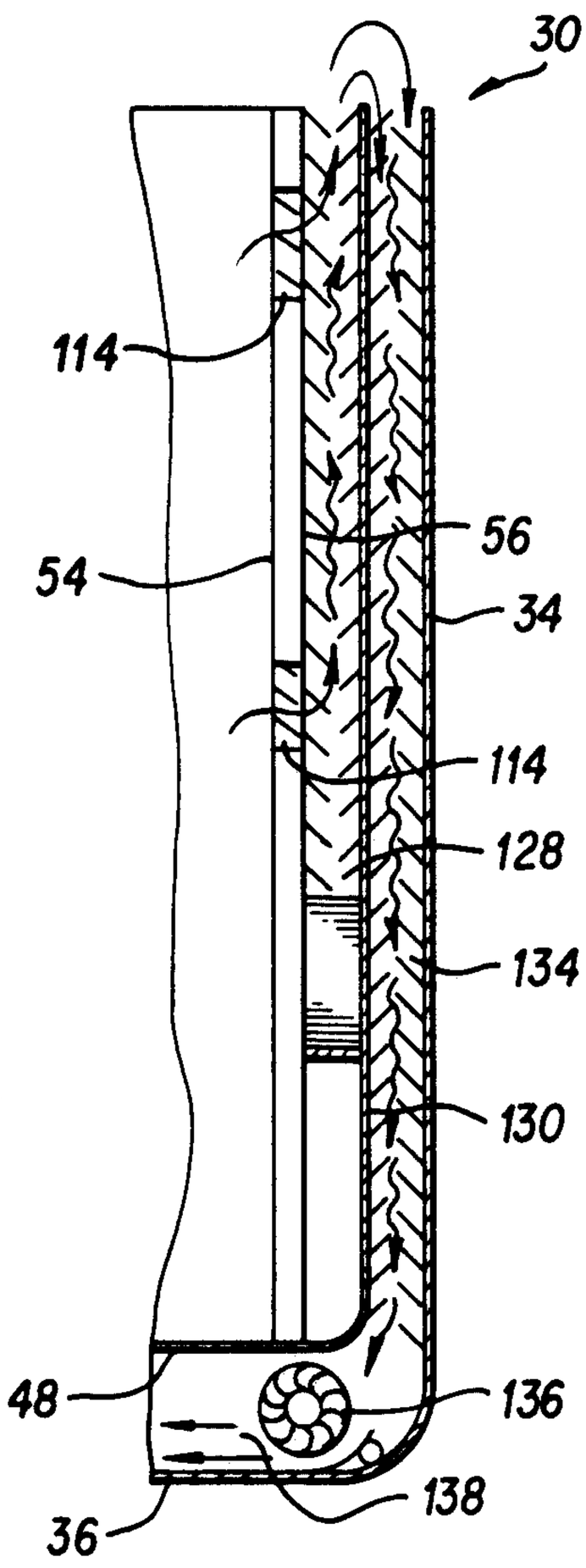


FIG. 8A

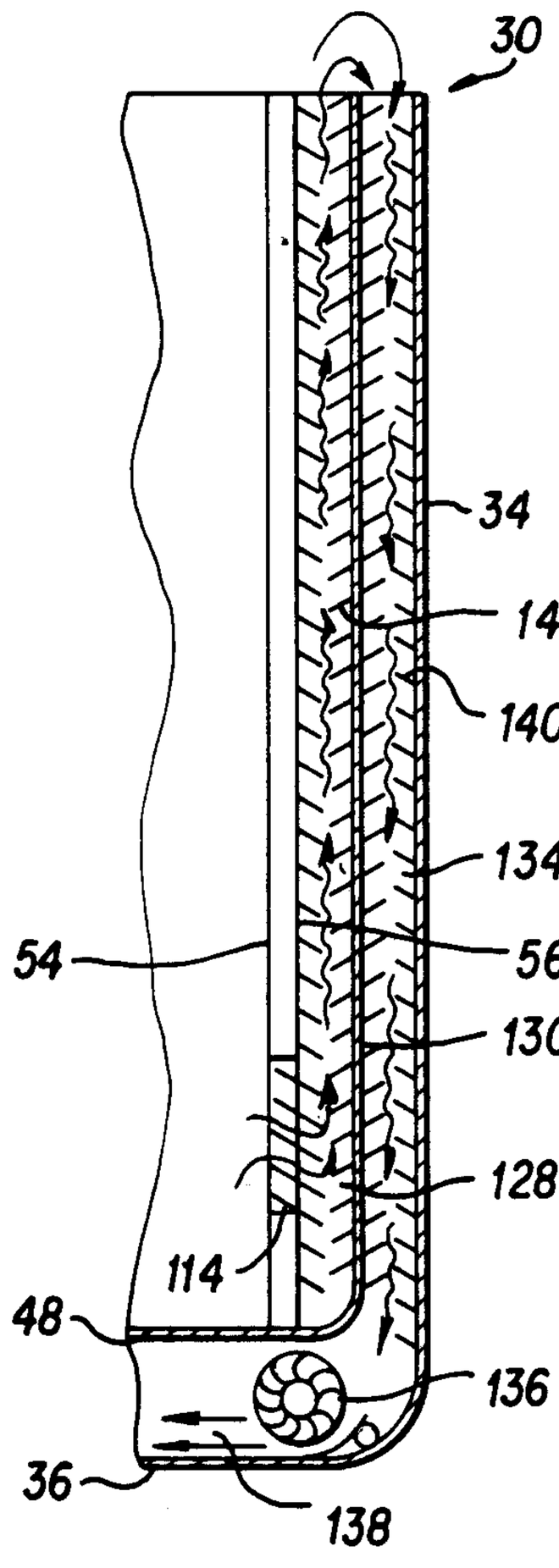


FIG. 8B

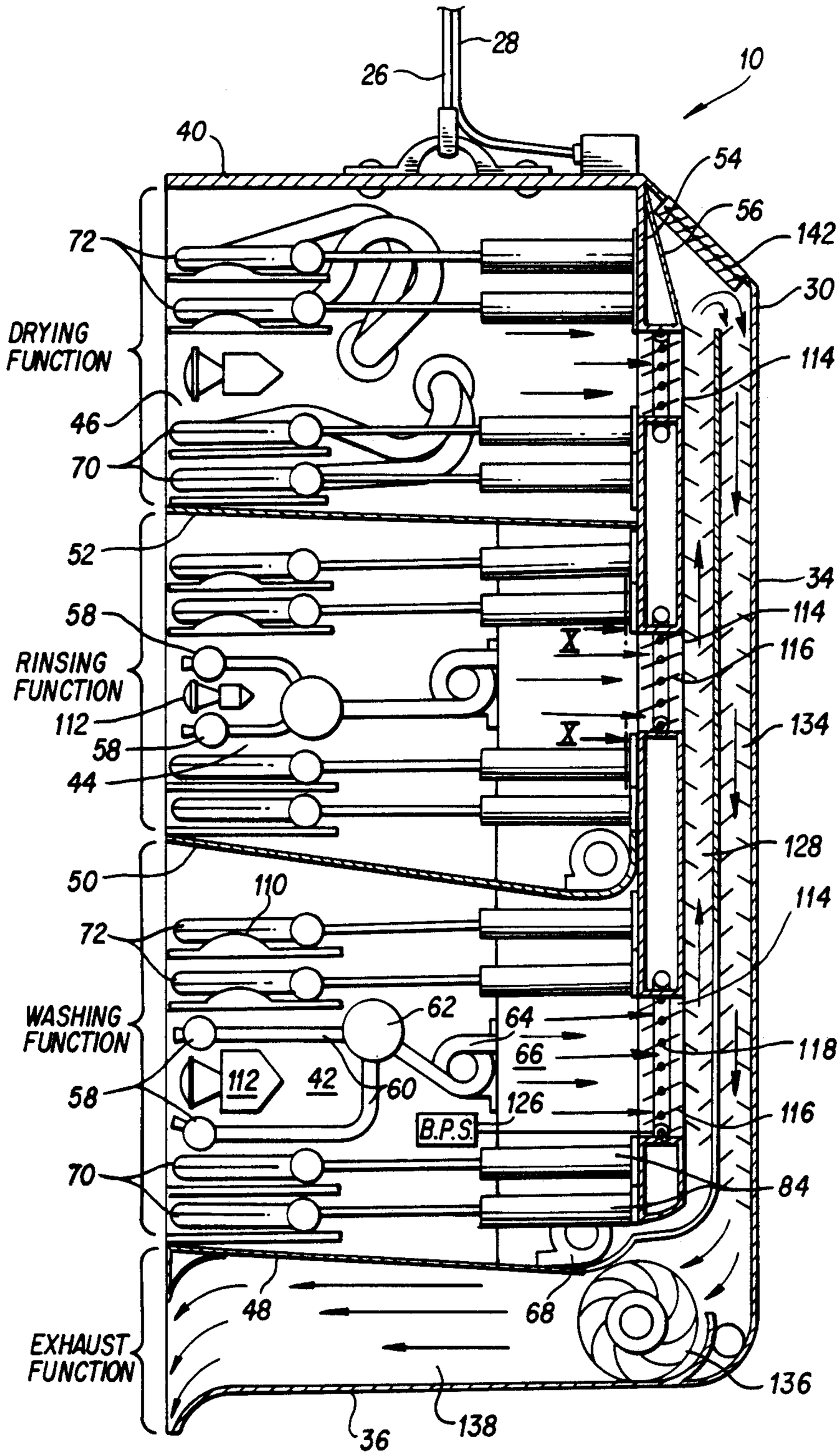
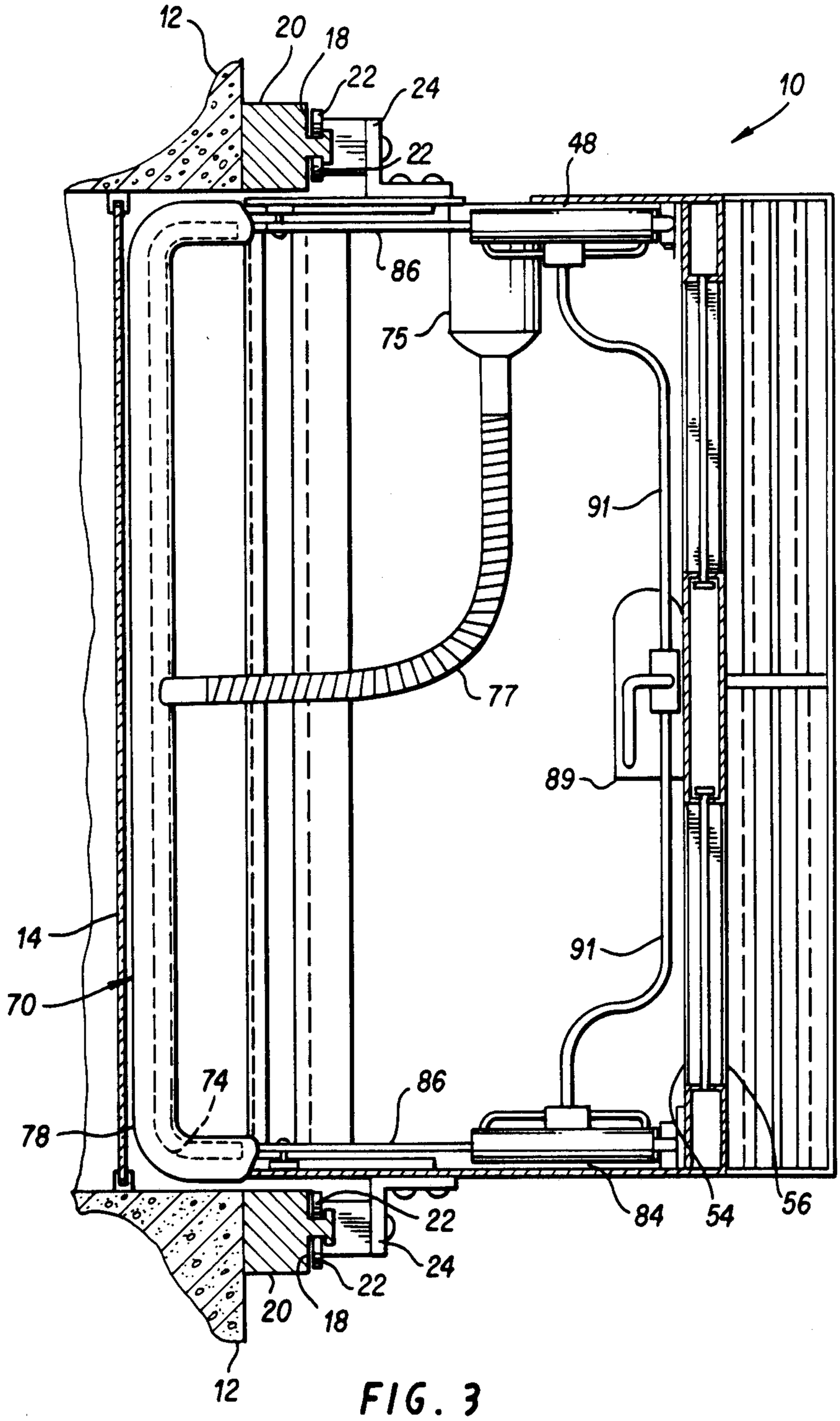

26
28
10
40
54
56
142
30
72
DRYING FUNCTION
114
46
70
52
34
58
114
RINSING FUNCTION
116
112
58
134
44
50
110
128
72
114
WASHING FUNCTION
62
64
66
118
112
42
60
58
126
116
B.P.S.
70
84
48
68
EXHAUST FUNCTION
136
36
138

FIG. 2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12

FIG. 3

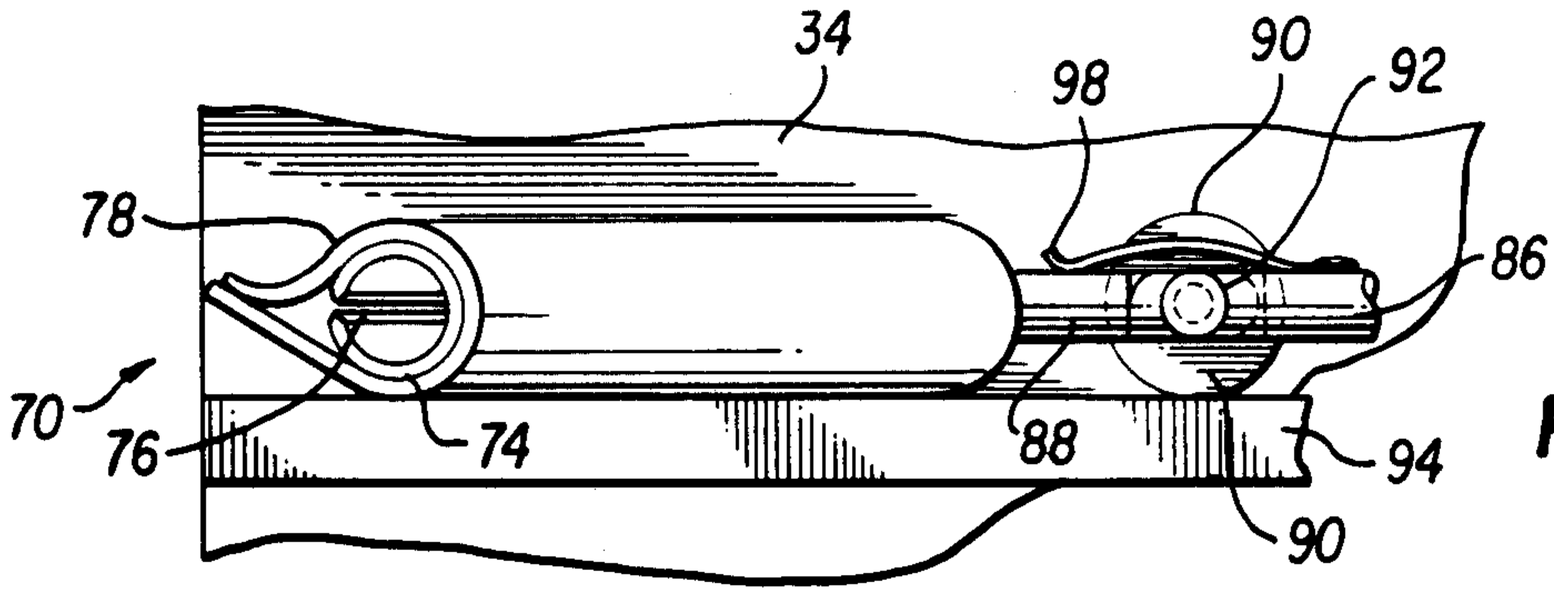


FIG. 4

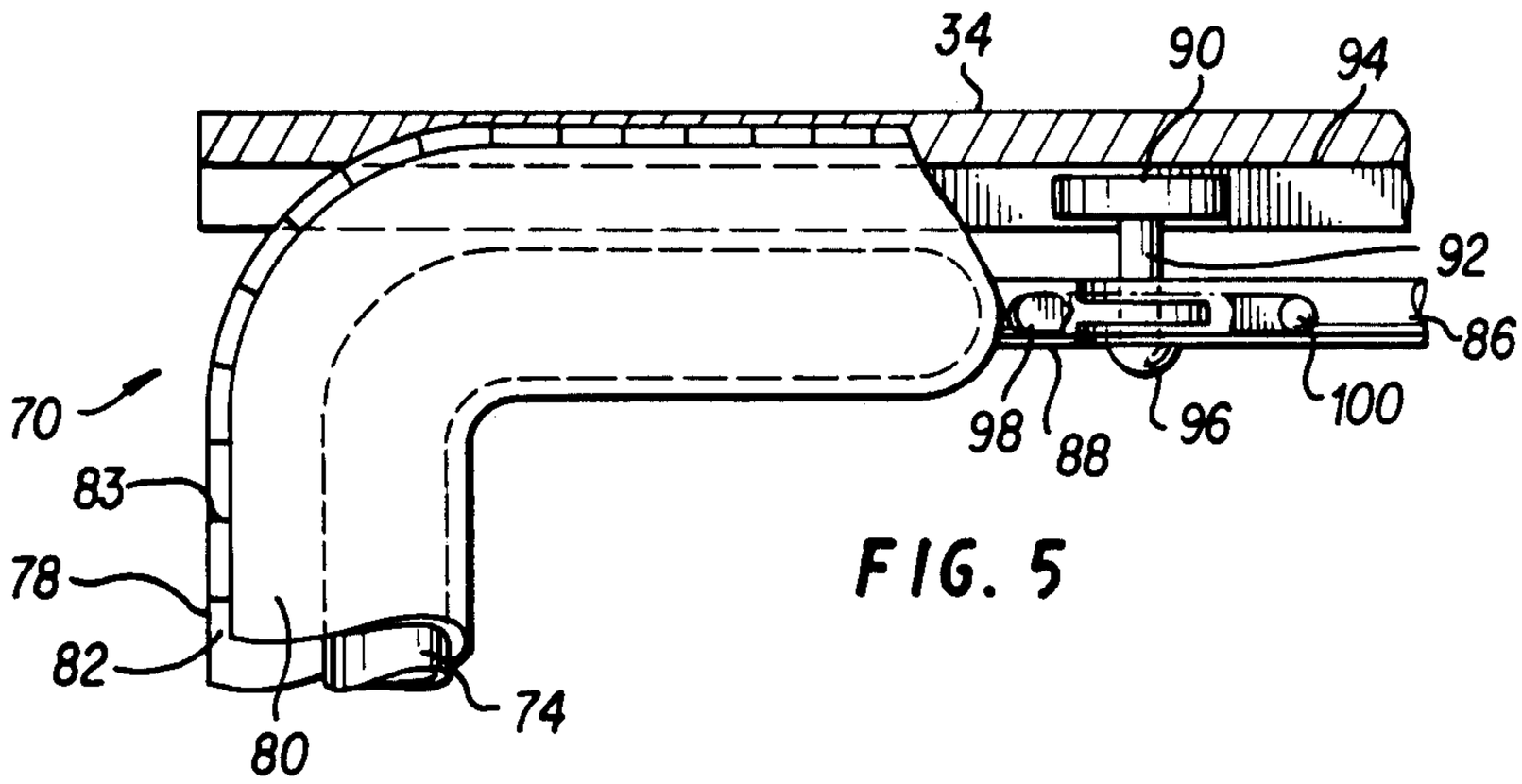


FIG. 5

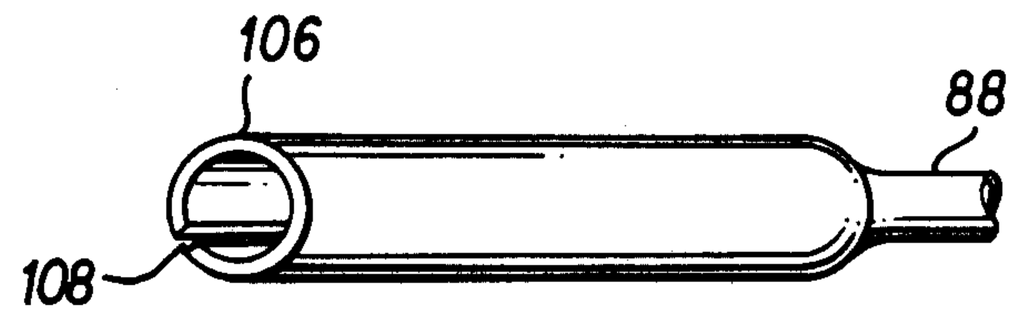


FIG. 6

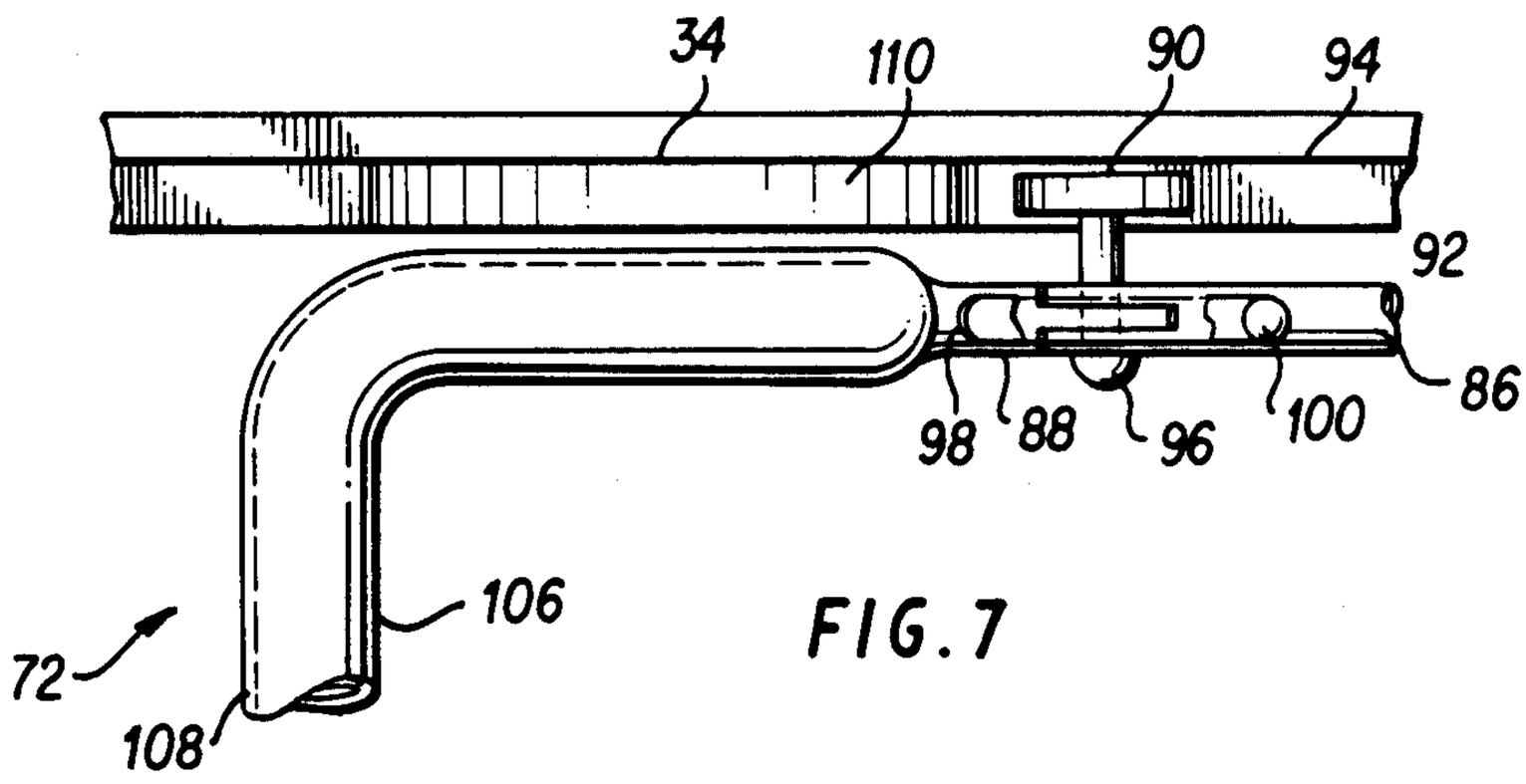


FIG. 7

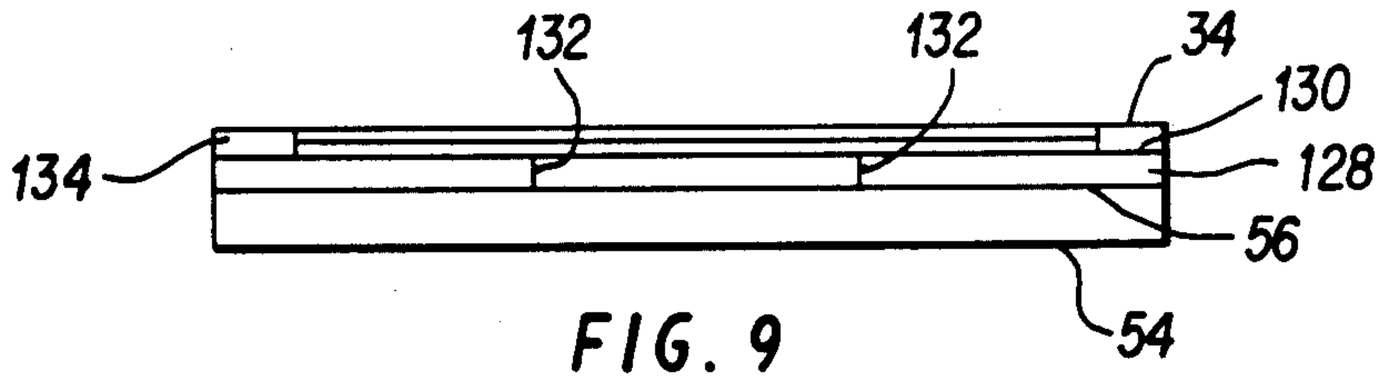


FIG. 9

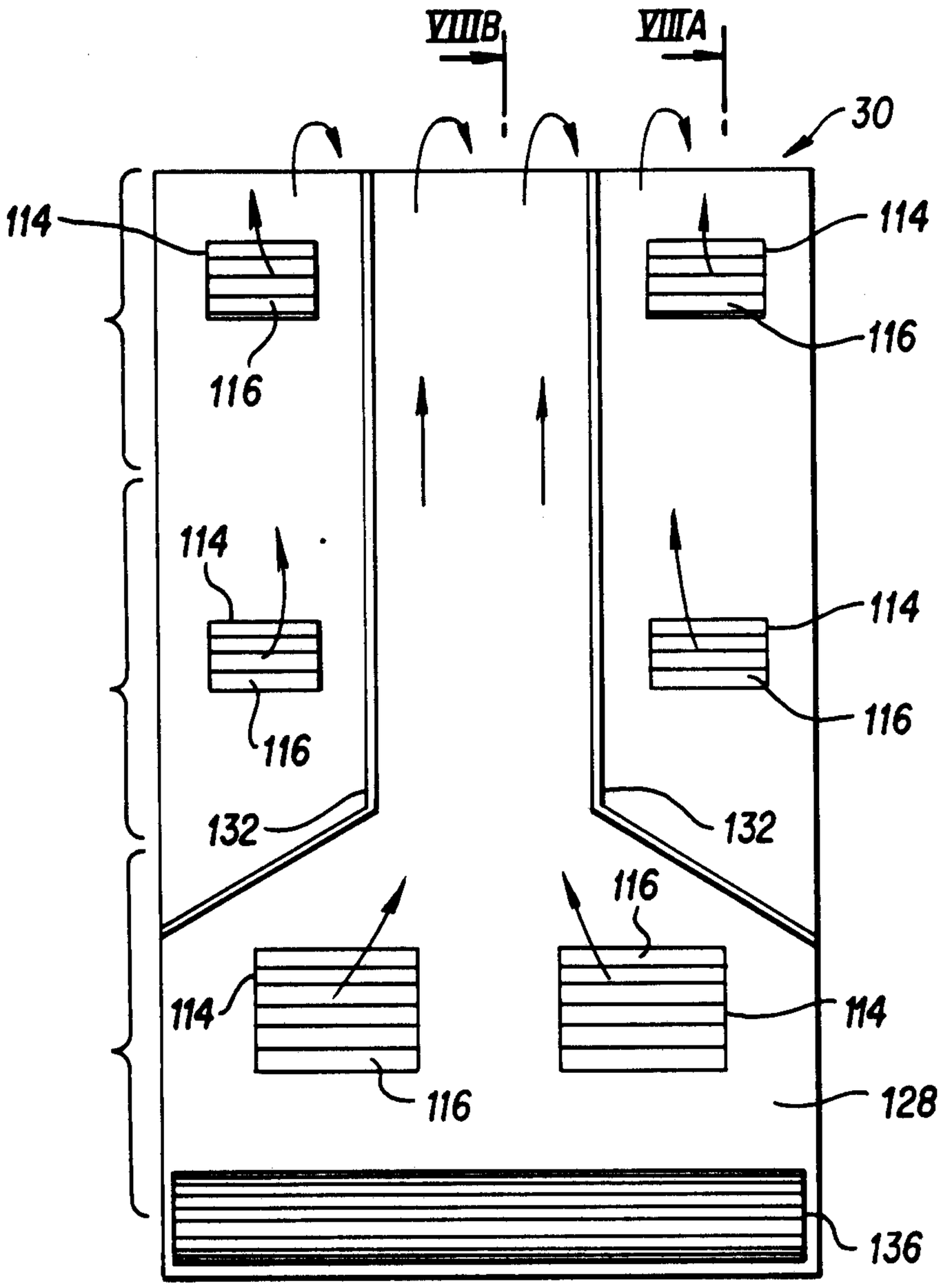
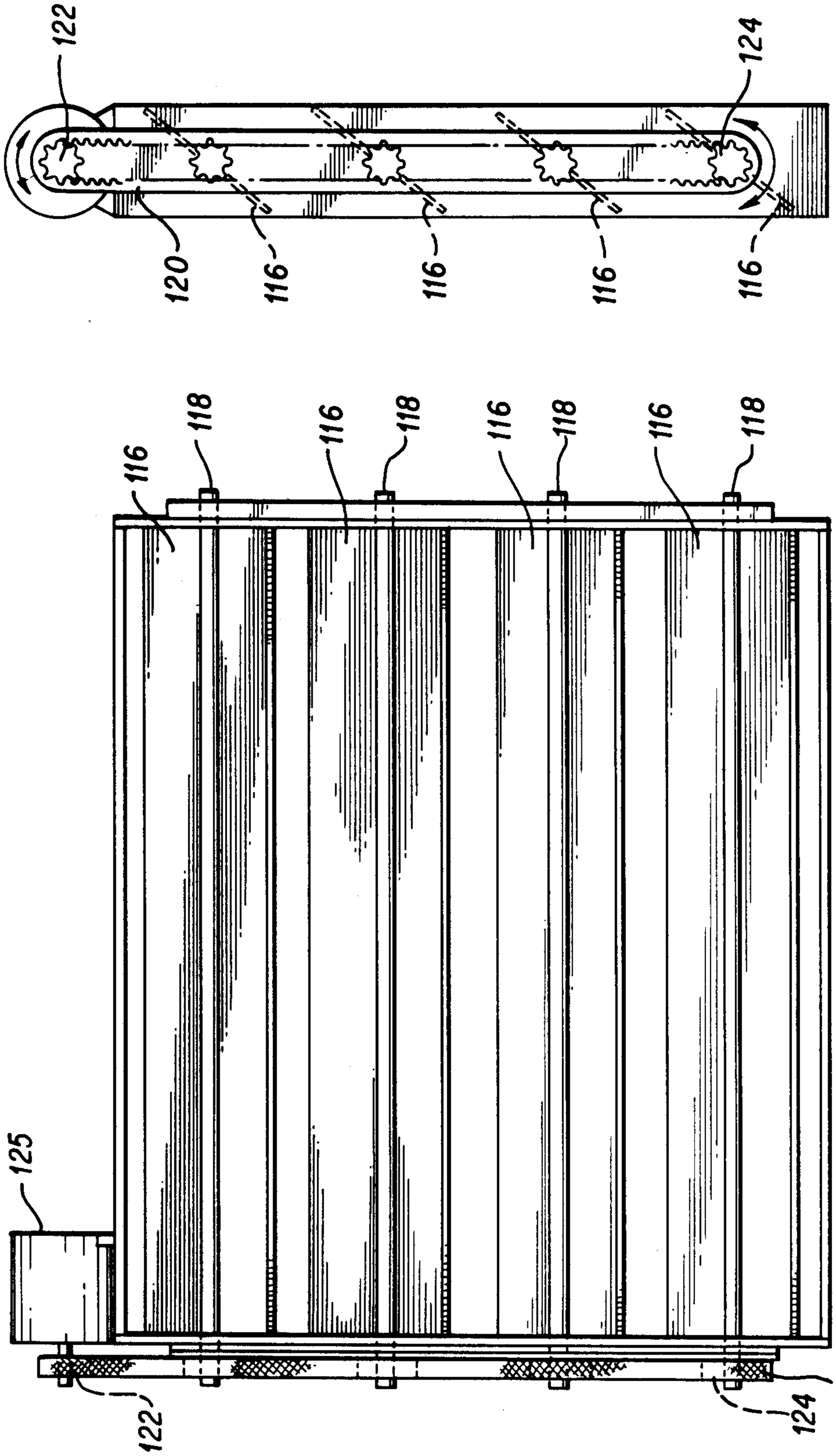


FIG. 8


122
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120

FIG. 10

FIG. 11

BUILDING EXTERIOR CLEANING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a self-contained apparatus for cleaning the vertical surface of a building exterior, including washing the windows, and more particularly to an apparatus which is positioned by an operator above a vertical row of windows and then remotely operated to clean the exterior building surface as the apparatus descends.

Description of the Prior Art

High-rise buildings having fixed glazing have become prevalent in recent years and continue to enjoy great popularity. These buildings have created the necessity of finding a way of cleaning the exterior surface, and architects have responded to the problem in many cases by providing some means of support of scaffolding in the building mullions. In many cases rails have been provided in the mullions so that automated washing machines may be used to clean the exterior building surface. A number of such automatic cleaning devices have been proposed, as for example U.S. Pat. No. 3,604,049 to Hetman; U.S. Pat. No. 3,942,213 to Hohner, Jr.; U.S. Pat. No. 4,025,984 to Hohner, Jr.; U.S. Pat. No. 4,136,419 to Hetman et al; and U.S. Pat. No. 4,198,724 to Fisher et al. It is generally conceded that such machines have not experienced wide acceptance and that a number of problems exist in their application.

U.S. Pat. No. 3,942,213, to Hohner, Jr., for example, describes a wall washing device which uses an air curtain to contain the liquid sprayed against the building exterior. A fan is provided to induce the flow of mist away from the cleaning area and then use the demisted air as an air curtain. The described apparatus, however, employs only a single section for all cleaning functions, and thus is likely to leave a dirty or streaked surface. Nor are means provided for sequencing individual functions, i.e., fluid spray, brushing, wiping, for inset windows, thereby leaving areas at the top and bottom of windows only partially cleaned. In addition, there are no means provided for regulating the pressure in the cleaning chamber and it is thus possible that dirty mist may circulate therein and not be effectively removed.

An additional problem encountered by previous automated washing devices is that of loosening the dirt from the building surface. The prior art means of agitating the dirt loose include direct brush scrubbing, spraying of a liquid, and blowing an air curtain against the surface. Use of air and liquid sprays have been considered to be more desirable than brushing since no direct contact is necessary. However, in the devices, the only way to enhance the loosening power of the spray is to increase the spray pressure, which is inefficient.

SUMMARY AND OBJECTS OF THE INVENTION

In view of the foregoing drawbacks of the prior art cleaning apparatus, as well as other disadvantages not specifically mentioned above, it should be apparent that there exists a need in the art for a cleaning apparatus which is more efficient and effective in removing dirt from the building exterior. It is, therefore, a primary objective of this invention to fulfill this need by providing a means for separating the washing, rinsing and drying chambers and regulating the pressure within said chambers of a building exterior cleaning apparatus.

More particularly, it is an object of this invention to provide axially rotating vanes in openings of the rear wall of the washing chamber, rinsing chamber, and drying chamber so that the size of the openings may be varied to regulate the pressure in the chambers.

It is another object of this invention to provide pressure sensors operatively connected to the vanes in the washing chamber and the drying and rinsing chambers so that the vanes may be rotated to vary the size of the openings in response to the pressure detected in the chambers.

Another primary object of this invention is to provide a building exterior cleaning apparatus having a sonic agitator disposed in the washing chamber for impinging a flow of sonic wave energy of the fluids on the building exterior in order to loosen contaminants covering the surface.

Still another object of this invention is to provide a vertical building exterior surface cleaning apparatus having a sonic agitator disposed in the washing chamber wherein the sonic agitator is so positioned with respect to the fluid spray heads as to give maximum impact to the sonic wave energy emitted by the sonic agitator, thereby creating a cavitational effect on the building surface sufficient to dislodge surface contamination.

Yet another object of the invention is to provide a vertical building exterior surface cleaning apparatus having a sonic agitator disposed in the rinsing chamber and mounted so as to impinge sonic wave energy onto the fluids which contact the surface of the building exterior.

Still another object of the invention is to provide a vertical building exterior surface cleaning apparatus having a sonic agitator disposed in the drying chamber and mounted so as to impinge sonic wave energy onto any fluids which remain on the surface of the building exterior after rinsing has been completed.

Still another object of the invention is to provide for individual movement and control of functions within the washing, rinsing and drying chambers.

Briefly described, the aforementioned objects are accomplished according to the invention by providing a housing having a washing chamber, a rinsing chamber, and a drying chamber, the washing chamber having a plurality of spray heads for impinging a cleaning fluid on the surface of the building exterior, a plurality of air seals for retaining the fluid in the chamber, and a plurality of air wipes for removing the fluid from the building surface.

The rinsing chamber has a plurality of spray heads for impinging a clean rinsing liquid against the surface of the building exterior, and also a plurality of air seals to contain the rinsing fluid within the chamber and a plurality of air wipes for removing the fluid from the building surface. Openings are provided in the washing chamber, rinsing chamber, and drying chamber, the openings communicating with a passageway which ends with an outside exhaust outlet. The passageway contains baffles designed to create turbulence, thereby causing droplets to form sufficiently large so as to drop from the atmosphere and be recirculated.

An exhaust blower disposed in the passageway maintains a negative pressure in each of the washing chamber, rinsing chamber, and drying chamber, a plurality of axially rotatably mounted vanes are disposed in the

openings so that the size of the openings may be varied in order to regulate the negative pressure.

Pressure sensors are located within each of the washing chamber, rinsing chamber, and drying chamber and are operatively connected to the vanes so as to vary the sizes of the openings, and thus regulate the pressure in the chambers, in response to the actual pressure therein.

Also disposed in the washing chamber is a sonic agitator which is mounted so as to imping sonic wave energy onto the fluids on the surface of the building exterior. The sonic agitator cooperates with the liquid spray heads and angled air seals to agitate and remove dirt from the glazed panel surface.

Sonic agitators may also be disposed in either the rinsing chamber or drying chamber, or both. When a sonic agitator is disposed in the rinsing chamber it is mounted so as to impinge sonic wave energy onto the rinsing fluids which are sprayed onto the surface of the building exterior. When a sonic agitator is disposed in the drying chamber, it is mounted so as to impinge sonic wave energy onto any fluids which remain on the surface of the building exterior after rinsing has been completed.

With the foregoing and other objects, advantages and features of the invention which will be become hereinafter apparent, the nature of the invention may be more clearly understood by reference to the following detailed description of the invention, the appended claims, and to the several views illustrated in the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the cleaning apparatus according to the invention in position on the vertical surface of a building exterior.

FIG. **1***a* is a plan view of a portion of the cleaning apparatus according to the invention showing one embodiment for guiding the cleaning apparatus for vertical movement.

FIG. **2** is a sectional view showing the interior arrangement of the elements of the invention, taken along a vertical plane passing through line II—II of FIG. **1**.

FIG. **3** is a sectional view showing, in particular, the washing chamber of the inventive apparatus taken along a horizontal plane passing through line III—III of FIG. **1**.

FIG. **4** is a partial elevation showing the air seals of the cleaning apparatus according to the invention.

FIG. **5** is a plan view of FIG. **4**.

FIG. **6** is a partial elevation showing the air wipes of the cleaning apparatus according to the invention.

FIG. **7** is a plan view of FIG. **6**, with some additional detail illustrated.

FIG. **8** is a rear elevation of the cleaning apparatus of the present invention with the rear cover removed, illustrating the flow of fluid within the exhaust section of the cleaning apparatus.

FIGS. **8A** and **8B** are sectional views taken along lines VIIIA—VIIIA and VIIIB—VIIIB of FIG. **8**, respectively.

FIG. **9** is a plan view of FIG. **8**.

FIG. **10** is an enlarged detail taken along line X—X of FIG. **2**, showing the vane drive mechanism according to the invention.

FIG. **11** is a side elevational view of the vane drive mechanism shown in FIG. **10**.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now in detail to the drawings, wherein like parts are designated by like reference numerals throughout, there is illustrated in FIG. **1** a cleaning apparatus constructed according to a preferred embodiment of the inventon and designated generally by reference numeral **10**. Cleaning apparatus **10** is contained within mullions **12** of a high rise building having a building exterior surface formed by fixed glazed panels **14** interspersed with building panels **16** made from a generally decorative building material such as marble or granite slabs, painted steel sheets, porcelain enameled aluminum or steel sheets, anodized aluminum sheets, ceramic tile or the like.

As shown in **1***a*, cleaning apparatus **10** is guided for vertical movement in guide tracks **18** provided in mullions **12** by means of guide wheels **22** mounted on the outside of cleaning apparatus **10**. In another embodiment, as shown in FIG. **3**, cleaning apparatus **10** is guided in guide tracks **18**, mounted to mullions **12** by means of guide rails **20**, and by guide wheels **22**, mounted on the outside of cleaning apparatus **10** by brackets **24**.

Cleaning apparatus **10** is suspended from the roof of the building by cable **26**, and is supplied with electrical power through electrical cable **28**. Cleaning apparatus **10** is provided with a housing **30** comprising rear wall **32**, side walls **34**, bottom wall **36**, and top wall **40**.

With reference now to FIG. **2**, cleaning apparatus **10** is provided in its interior with 3 superpositioned chambers; a washing chamber **42**, a rinsing chamber **44**, and a drying chamber **46**. Washing chamber **42**, rinsing chamber **44**, and drying chamber **46** perform the washing, rinsing, and drying functions, respectively. Three laterally extending floor panels, washing chamber floor panel **48**, rinsing chamber floor panel **50**, and drying chamber floor panel **52** are provided across the extent of the interior of the cleaning apparatus **10**. A pair of vertically extending wall panels, inner chamber wall panel **54**, and outer chamber wall panel **56** provide a common rear wall for each of the chambers. Thus, side walls **34** (FIG. **1**) of housing **30**, washing chamber floor panel **48**, rinsing chamber floor panel **50** and inner chamber wall panel **54** define the washing chamber **42**. Similarly, rinsing chamber **44** is defined by side walls **34**, rinsing chamber floor panel **50**, drying chamber floor panel **52**, and inner chamber wall panel **54**. Drying chamber **46** is defined by side walls **34**, drying chamber floor panel **52**, top wall **40**, and inner chamber rear wall **54**.

Disposed within washing chamber **42** are the various elements used for the washing function. Fluid spray heads **58** are fed through supply hoses **60** from a fluid manifold **62** which is fed by supply hose **64** from a detergent tank **66**. Detergent tank **66** is provided with suction pump **68** for pumping the detergent in tank **66** through manifold **62** and eventually spray heads **58**. It will be noted that washing chamber floor panel **48** is canted toward the base of tank **66** to thereby allow fluids to be recycled. Suitable filters (not shown) are provided to remove the dirt which is washed off the building exterior from the recycled fluid. Also disposed within washing chamber **42** are a plurality of air seals **70** and a plurality of air wipes **72**.

Air seals **70** are disposed beneath spray heads **58** and are arranged so as to impinge an upwardly directed flow of air against the building exterior surface. The

purpose of air seals **70** is two-fold. First the air seals contain the fluid which is sprayed onto the surface of the building exterior and prevent fluid from escaping. Second, the air flow acts to loosen dirt on the surface of the building exterior. Air wipes **72** are disposed above spray heads **58** and are arranged so as to impinge a downwardly directed flow of air against the building exterior surface, and are used primarily to contain the fluids sprayed by spray heads **58** and act as an air squeegee to remove fluids and contaminants from the building surface.

Referring to FIG. **3** and with further reference to FIGS. **4**, **5**, **6**, and **7**, details of the construction of air seals **70** and air wipes **72** are seen. Air seals **70** comprise a central air tube **74** having a slot **76** in its outer periphery. Tube **74** and slot **76** extend laterally across the entire face of the front of the cleaning apparatus and are arranged so as to impinge a continuous air flow across the front of washing chamber **42**. Surrounding tube **74** is a flexible sealing skirt **78** which has an upper flap **80** resting thereon to define a skirt opening **82**. Pressurized air is supplied to tube **74** by means of an air blower **75** and flexible hosing **77**. The air flows out of tube **74** through slot **76** and then out opening **82** to be upwardly directed against the exterior building surface across the entire face of washing chamber **42**. Fluid which is sprayed through spray heads **58** against the building's exterior surface is thus trapped by air seals **70** and air wipes **72** (described hereinafter) and returned into the interior of washing chamber **42** where it falls down to washing chamber floor **48** to be collected at the bottom of water tank **66**. Sealing skirt **78** is further provided with a plurality of vertically slotted serrations **83** which allow more effective modification of skirt **78** in its sealing function to vertcial support members of windows where so encountered. Thus, when the compressed air curtain strikes sealing skirt **78** it is forced in a flexible manner outwardly towards the juxtaposed exterior building surface to establish a contacting but slideable seal with the vertical surface. The seal can vertically traverse the vertical surfaces from top to bottom as the cleaning device proceeds downwardly with respect to the building face.

Air seals **70** are arranged for lateral extension and withdrawal by a plurality of pneumatic cylinders **84** (FIGS. **2** and **3**) through piston shafts **86** and hinge butt shafts **88**. A wheel **90** is mounted for free rotation about a wheel shaft **92**. Wheel **90** is supported by a horizontal guide means **94** which is fixed with respect to the sidewall **34** of the cleaning apparatus. Wheel shaft **92** is retained on piston shaft **86** and hinge butt shaft **88** by retainer **96**. A tension spring **98** is retained at one end of piston shaft **86** by a fastener **100**. The other end of tension spring **98** engages hinge butt shaft **88** so as to exert a constant tension tending to maintain piston shaft **86** and hinge butt shaft **88** at a horizontal rest position. A hydraulic pump **89** feeds hydraulic fluid through supply lines **91** to hydraulic cylinders **84**. Thus, when the hydraulic pump is actuated through appropriate controls (not shown), such as sensors which are located at the front of the cleaning apparatus to detect variations in the building exterior surface, hydraulic cylinders **84** are actuated to extend or withdraw air seal **70**. When air seal **70** is extended or withdrawn by operation of piston shaft **86** and hinge butt shaft **88**, air seal **70** is maintained in a horizontal position by wheel **90** riding along its horizontal guide means **94** with the cooperation of springs **98**. Air seals **70** are extended toward and withdrawn from the vertical surface of the building exterior in order that they may appropriately contact the building surface during the washing operation or be withdrawn from the building surface in order to allow the seals to pass safely over the building muntins.

Air wipes **72**, as shown in FIGS. **6** and **7**, comprise an air distribution tube **106** extending laterally across the entire face of the washing chamber **42**. Tube **106** has a slot **108** in the lower, outwardly quadrant so as to direct a flow of air downwardly against the vertical surface of the building exterior when the tube **106** is juxtaposed against the building surface. Similar to air seals **70**, air wipes **72** are extended toward and withdrawn from the vertical surface of the building exterior by means of piston shaft **86** connected with hinge butt shaft **88** mounted on wheel shaft **92** of wheel **90**, supported on horizontal guide means **94**. In addition, however, horizontal guide means **94** is provided with a camming surface **110** (see also FIG. **2**), which raises the air wipe **72** together with slot **108** of air distributing tube **106** when the air wipe **72** is extended towards the vertical surface of the building exterior. Air wipes **72** thus begin the wiping function at the extreme upward portion of a window.

Air wipes **72** are provided, similar to air seals **70**, with corresponding hydraulic cylinders, a hydraulic pump, and controls so as to extend air shields **70** toward and retract air shield **70** from the verticl surface of the building exterior.

Referring again to FIG. **2**, disposed within washing chamber **42** is a sonic agitator **112**. Sonic agitator **112** is disposed so as to impinge a flow of sonic wave energy on the vertical surface of the building exterior when the cleaning apparatus **10** is juxtaposed to the building exterior. Sonic agitator **112** is further positioned between fluid spray heads **58**. Thus, when a stream of fluid is being directed against the vertical surface of the building exterior, there will be a combination of fluids and fluid mist in the region between the sonic agitator and the vertical surface of the building exterior. This combination of fluid and fluid mist provides the medium for the passage of the sonic waves which are generated by sonic agitator **112**.

Sonic agitator **112** is designed so as to produce the appropriate frequency and strength of sonic waves against the vertical surfaces of the building exterior so as to agitate loose particles of dirt which have accumulated on the building exterior. Sonic agitator **112** is provided with an appropriate power source and controls (not shown).

Sonic agitator **112** may be any type of commercially available sonic agitator such as those available from the Sonic Instrument Corp. of Copiague, N.Y.; Ultrasonic Resources Corp. of Roslyn, N.Y.; or Sonic Sonic Systems Inc. of Newtown, Pa. Other suitable sonic agitors may found by consulting the Thomas Register.

Optionally disposed within rinsing chamber **44** is an additional sonic agitator **112** which is mounted so as to impinge sonic wave energy onto the rinsing fluids which contact the surface of the building exterior. Sonic agitator **112** of rinsing chamber **44** is further positioned between fluid spray heads **58** of rinsing chamber **44**. Sonic agitator **112** of rinsing chamber **44** operates similarly to sonic agitator **112** of washing chamber **42** and accordingly a separate description has not been provided.

Optionally disposed within drying chamber **46** is an additional sonic agitator **112** which is mounted so as to

impinge sonic wave energy onto any fluids which remain on the surface of the building exterior after rinsing has been completed. Since no fluid spray heads **58** are disposed in drying chamber **46**, and thus the only source of fluid circulating in drying chamber **46** is the air which is supplied by air seals **70** and air wipes **72** and the fluids which remain on the surface of the building exterior after rinsing has been completed, it will be appreciated that conditions in drying chamber **46** differ from those in washing chamber **42** and rinsing chamber **44**. Accordingly, the frequency and strength of sonic waves generated by the sonic agitator in drying chamber **46** must be appropriately adjusted for these conditions.

With further reference to FIG. **2** of the drawings and with reference now to FIGS. **8**, **9**, **10** and **11**, provided at the rear of washing chamber **42**, rinsing chamber **44**, and drying chamber **46**, are rear openings **114**, defined by inner chamber wall panel **54** and outer chamber wall panel **56**. Disposed within rear openings **114** are a plurality of pressure control vanes **116**. Each of the pressure control vanes **116** are mounted for controlled axial rotation about a rod **118**. A toothed drive belt **120** interconnects a plurality of vanes **116** and is stretched between upper and lower gears **122**, **124**, respectively. Upper gear **122** is connected to a dual direction servo motor **125** which is energized in response to a barometric pressure sensor **126** (FIG. **2**) located within chambers **42**, **44**, and **46**. For the sake of clarity in the drawings, only one barometric pressure sensor **126**, disposed in washing chamber **42**, is illustrated in the drawings, but it is to be understood that similar sensors are located in rinsing chamber **44** and drying chamber **46** for similar control of the flow of fluid within cleaning apparatus **10**.

As seen in FIGS. **8** and **8B**, openings **114** in washing chamber **42** open into an upward flow channel **128** formed at the rear of housing **30** in the space between an intermediate rear wall **130** and outer chamber wall panel **56**. As seen in FIGS. **8** and **8A**, openings **114** in rinsing chamber **44** and drying chamber **46** also open into upward flow channel **128**. Upward flow channel **128** is further sectioned into separate compartments by vertically extending compartment separators **132** (FIG. **8**). A downward flow channel **134** is formed in the space between intermediate rear wall **130** and rear wall **34** of the housing **30**. A large capacity radial vane air blower **136** is provided at the rear end of an exhaust channel **138** formed at the bottom of the housing **30** by bottom wall **36** and washing chamber floor panel **48**. Exhaust channel **138** terminates in an exhaust outlet which is open to the atmosphere so that fluids may be exhausted from the cleaning apparatus housing **30**. Air blower **136** acts to create a negative pressure in each of washing chamber **42**, rinsing chamber **44**, and drying chamber **46**. It is also to be understood that air blower **136** may be replaced by a number of blowers, disposed in each of the compartments of upward flow channel **128**, for individual compartment pressure control. The flow of air and fluid from each of the chambers, through openings **114**, upward flow channel **128**, downward flow channel **134** and exhaust channel **138** is illustrated by the arrows in FIGS. **2**, **8**, **8A** and **8B**. At the interior of upward flow channel **128** and downward flow channel **134**, a plurality of agitation vanes **140** are provided in order to create turbulance in the flow of fluid through channels **128**, **134**, thereby removing water droplets from the fluid being drawn through the channels by blower **136**. Also included at the top and to the rear of housing **30** are pressure control vanes **142** (FIG. **2**), which are rotatable similarly to pressure control vanes **116** in response to a pressure sensor arranged at the top of the confluence of channels **128** and **131** so that exterior air may be introduced to the channels if required when the pressure control vanes **116** are fully closed.

In operation, the building exterior cleaning apparatus **10** of the invention is positioned within a vertical column of building panels **14**, **16** from the roof of a building with the guide wheels **22** placed into guide tracks **18** on the building mullions **12**, supported by cable **26**. The cleaning apparatus **10** is lowered and the sequencing operation of the machine begins. Air seals **70** and air wipes **72** are extended toward the glazed panel **14** by hydraulic cyliners **84** within washing chamber **42** and air is blown into seal **70** and wipe **72** by blower **75**. Radial vane blower **136** is started to create a negative pressure in washing chamber **42**. Suction pump **68** is started to pump detergent from tank **66** through fluid spray heads **58** against glazed panel **14**. At the same time, sonic agitator **112** in washing chamber **42** is activated to impinge sonic wave energy onto the surface of glazed panel **14** via the fluids which contact the surface of the panel. As the cleaning apparatus **10** is lowered, the entire surface of the glazed panel **14** is cleaned, due to the action of the spray of fluid from spray heads **58** in conjunction with the sonic agitator **112** and with the cooperation of air seals **70** and air wipes **72**. During this time, the negative pressure created by blower **136** within washing chamber **42** will fluctuate as cleaning apparatus **10** goes through its cleaning cycle. The pressure within washing chamber **42** is sensed by barometric pressure sensor **126**, and in response to the pressure which is thereby measured, servo motor **124** is selectively energized to rotate pressure control vanes **116** to adjust the volume of air which is permitted to flow through opening **114**, thereby adjusting the pressure within washing chamber **42** to a desired predetermined pressure. The fluid which leaves opening **114** in washing chamber **42** is drawn by blower **136** through upward flow channel **128**, through downward flow channel **134** and exhausted into the atmosphere through exhaust channel **138**.

When the cleaning apparatus **10** has been sufficiently lowered to expose rinsing chamber **44** to the glazed panel **14**, the operating cycle of the machine operates to activate hydraulic cylinders **84** within rinsing chamber **44** to advance air seals **70** and air wipes **72** within rinsing chamber **44** against the glazed panel **14**. Air is blown through air seals **70** and air wipes **72** in rinsing chamber **44** as described above with regard to the seals and wipes of washing chamber **42**. The pump of the rinse water tank is then activated and rinse water is sprayed from fluid spray heads **58** onto glazed panel **14**. Sonic agitator **112** in rinsing chamber **44** is also activated and generates sonic wave energy to loosen contaminants on the glazed panel which may have escaped the washing operation. As the rinsing operation continues, pressure within the rinsing chamber **44** will vary, and a barometric pressure sensor located within rinsing chamber **44** operates to rotate pressure control vanes **116** in rinsing chamber **44** to control the size of opening **114** in rinsing chamber.**44**. Fluid which flows from rinsing chamber **44** through opening **114** is directed into upward flow channel **128**, into downward flow channel **134**, drawn by blower **136**, and is exhausted into the atmosphere through exhaust channel **138**.

As cleaning apparatus **10** continues to be lowered, drying chamber **46** is exposed to glazed panel **14** and the operating cycle activates hydraulic cylinders **84** of drying chamber **46** to advance air seals **70** and air wipes **72** of drying chamber **46**. Sonic agitator **112** of drying chamber **46** is activated and generates sonic wave energy which impinges against glazed panel **14** via fluids which remain on the panel after rinsing has been completed, thereby further agitating loose from the surface of panel **14** any contaminants which may have escaped the washing and rinsing operations. Negative pressure created within drying chamber **46** by blower **136**, in combination with air which is blown on the panel by air seals **70** and air wipes **72**, acts to dry the surface of glazed panel **14**. During the course of drying operation, the pressure within drying chamber **46** will vary. In order to control this variation, a barometric pressure sensor is located in drying chamber **46** and connected with presssure control vanes **116** positioned within opening **114** of drying chamber **46** to adjust the size of the opening and thus control the pressure within drying chamber **46**. Fluids which are removed from drying chamber **46** pass through opening **114** and are directed into upward flow channel **128**, into downward flow channel **134**, drawn by blower **136**, and pass through exhaust channel **138** where they are exhausted to the atmosphere.

As the cleaning apparatus **10** continues on its vertical descent, each glazed panel **14** is successively washed, rinsed, and dried by the functioning of the various section of the cleaning apparatus until the lowermost glazed panel **14** has been cleaned. The operational cycle of the machine then deactivates all machine functions, cleaning apparatus **10** is hauled to the roof, and repositioned in the next successive pair of mullions and the cycle is recommenced.

Although only preferred embodiments are specifically illustrated and described herein, it will be appreciated that many modifications and variations of the present invention are possible in light of the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.

I claim:

1. A vertical building exterior cleaning apparatus comprising:

a housing;

a washing chamber disposed in said housing, said washing chamber having means for impinging a cleaning fluid on the building exterior;

a rinsing chamber disposed in said housing, said rinsing chamber having means for impinging a rinsing fluid on the building exterior;

means for maintaining a negative pressure in the interior of said washing and rinsing chambers; and

means for regulating the negative pressure in said washing chamber and said rinsing chamber;

wherein said washing and said rinsing chambers have openings defined therein and said means for regulating the negative pressure in said washing chamber and said rinsing chamber comprises a plurality of vanes axially rotatably mounted in said openings for varying the size of said openings.

2. The vertical building exterior cleaning apparatus of claim **1** wherein said means for maintaining a negative pressure in said washing chamber and said rinsing chamber comprises an exhaust blower disposed in a passageway communicating at one end with an outside exhaust outlet and at the other end with said washing chamber opening and said rinsing chamber opening.

3. The vertical building exterior cleaning apparatus of claim **2** wherein said passageway, in the area between said chamber openings and said exhaust blower, comprises a plurality of baffles for removal of water vapor from air passing through said passageway.

4. The vertical building exterior cleaning apparatus of claim **1** further comprising:

a pressure sensor located in said washing chamber operatively connected with the vanes mounted in the opening of the washing chamber wherein the size of said washing chamber opening may be varied in response to the pressure in said washing chamber; and

a pressure sensor located in said rinsing chamber operatively connected with the vane mounted in the opening of the rinsing chamber wherein the size of said rinsing chamber opening may be varied in response to the pressure in said rinsing chamber.

5. The vertical building exterior cleaning apparatus of claim **1** further comprising:

a drying chamber disposed in said housing, said drying chamber being exposed to the building exterior;

means for maintaining a negative pressure in said drying chamber whereby fluids on the surface of the building exterior are drawn from the surface of the building exterior into said drying chamber; and

means for regulating the negative pressure in said drying chamber.

6. The vertical building exterior cleaning apparatus of claim **5** wherein said drying chamber has an opening defined therein and said means for regulating the negative pressure in said drying chamber comprises a plurality of vanes axially rotatably mounted in said opening for varying the size of the opening.

7. The vertical building exterior cleaning apparatus of claim **6** wherein said means for maintaining a negative pressure in said drying chamber comprises an exhaust blower disposed in a passage way communicating at one end with an outside exhaust outlet and at the other end with said drying chamber opening.

8. The vertical building exterior cleaning apparatus of claim **7** wherein said passageway, in the area between said chamber opening and said exhaust blower, comprises a plurality of baffles for removal of water vapor from air passing through said passageway.

9. The vertical building exterior cleaning apparatus of claim **8** further comprising:

a pressure sensor located in said drying chamber operatively connected with the vanes mounted in the opening of the drying chamber wherein the size of said dryer chamber may be varied in response to the pressure in said drying chamber.

10. The vertical building exterior cleaning apparatus of claim **5** wherein said means for impinging a flow of cleaning fluid on the building exterior comprises a plurality of fluid spray heads and said sonic agitator is positioned between said fluid spray heads.

11. A vertical building exterior cleaning apparatus comprising:

a washing chamber having means disposed therein for impinging a flow of cleaning fluid on the building exterior; and

a sonic agitator disposed in said washing chamber for impinging a flow of sonic wave energy on said building exterior.

12. The vertical building exterior cleaning apparatus of claim 11 further comprising:

a rinsing chamber having means disposed therein for impinging a flow of rinsing fluid on the building exterior; and

a sonic agitator disposed in said rinsing chamber for impinging a flow of sonic wave energy on said building exterior.

13. The vertical building exterior cleansing appratus of claim 12 wherein said means for impinging a flow of rinsing fluid on the building exterior comprises a plurality of fluid spray heads and said rinsing chamber sonic agitator is positioned between said rinsing chamber fluid spray heads.

14. The vertical building exterior cleaning apparatus of claim 12 further comprising:

a drying chamber having means disposed therein for impinging a flow of drying fluid on the building exterior; and

a sonic agitator disposed in the drying chamber for impinging a flow of sonic wave energy on the building exterior.

15. The vertical building exterior cleaning apparatus of claim 11 further comprising:

a drying chamber having means disposed therein for impinging a flow of drying fluid on the building exterior; and

a sonic agitator disposed in the drying chamber for impinging a flow of sonic wave energy on said building exterior.

16. The vertical building exterior cleaning apparatus of claim 15 wherein said means impinging a flow of drying fluid on the building exterior comprises an air seal and an air wipe and said drying chamber sonic agitator is positioned between said seal and said air wipe.

17. The vertical building exterior cleaning apparatus of claim 15 wherein said means for impinging a flow of drying fluid on the building exterior comprises a plurality of air seals and a plurality of air wipes.

18. A vertical building exterior cleaning apparatus comprising:

a housing;

a washer chamber disposed in said housing, said washing chamber having means for impinging a cleaning fluid on the building exterior;

a rinsing chamber disposed in said housing, said rinsing chamber having means for impinging a rinsing fluid on the building exterior;

means for maintaining a negative pressure in the interior of said washing and rinsing chambers; and

means including vanes for regulating the negative pressure in said washing chamber and said rinsing chamber.

19. A vertical building exterior cleaning apparatus comprising:

a housing;

a washing chamber disposed in said housing said washing chamber having means for impinging a cleaning fluid on the building exterior;

a rinsing chamber disposed in said housing, said rinsing chamber having means for impinging a rinsing fluid on the building exterior;

means for sensing the pressure in said washing and rinsing chambers;

means for maintaining a negative pressure in the interior of said washing and rinsing chambers; and

means for responsive to said sensing means for regulating the negative pressure in said washing chamber and said rinsing chamber.

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